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FILING DATE: ***June 10, 2004***
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c)

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Additional inventors are being named on the separately numbered sheets attached hereto.

TITLE OF THE INVENTION (500 characters max)

ROTARY POSITION RESOLVER

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ENCLOSED APPLICATION PARTS (check all that apply)

X	Specification Number of Pages	3		CD(s), Number	
X	Drawing(s) Number of Sheets	10		Other (specify)	
	Application Data Sheet. See 37 CFR 1.76				

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT (check one)

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This invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

[X] No

[ ] Yes, the name of the U.S. Government agency and the Government contract number are :

Respectfully submitted, ATTORNEY DOCKET NO.: 006-514-000

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Gerry A. Blodgett

Gerry A. Blodgett

Rotary Position Resolver

Reference

1. United States Provisional Patent Application
Taylor et al. "LINEAR POSITION AND MOTION SENSOR AND CIRCUIT"

Abstract

Rotary position detectors are described that use sensor technology disclosed in Ref. 1.

Position sensors are described in Ref. 1 that project an electromagnetic field from a face of the sensor. Movement of a metal actuator across the face of the sensor causes a change in the electromagnetic field. Change in the field causes the circuit associated with the sensor to change its output. This change in output is used to indicate position of the actuator relative to the sensor. By making the actuator in a spiral or helical shape and attaching that actuator to a rotating shaft, rotary position of the shaft can be determined.

Background

Various technologies are used for determining the angular position of an object about an axis of rotation. Optical, electrical, electrostatic and magnetic fields are all used with apparatus to measure position. There are many known apparatus for using these energies for sensing angular position. A few are resistive contacting sensors, inductively coupled ratio detectors, capacitively coupled ratio detectors, optical detectors using the Faraday effect, photo-activated ratio detectors, radio wave directional comparators, electrostatic ratio detectors and variable reluctance devices. There are many others.

The advancements disclosed in Ref 1 with regard to variable reluctance devices is exploited here with relation to rotary position sensing.

Description

Fig 1 shows the sensor circuit of the present invention. The circuit has two main functional blocks, a regulated power supply and a tuned oscillator circuit.

The function of the regulated power supply is to allow the device to work on an input voltage of 8 – 50VDC. The positive voltage is applied to pin 3 of connector CT1 and ground (return) is applied to pin 1. An on board regulated +5VDC supply (U1) is used to power the oscillator functional block. This voltage regulator has a maximum input voltage of +16VDC. The transistor Q1 with the base voltage limited to 15VDC via the zener diode D1, keeps the input voltage to U1 below the maximum tolerance.

The tuned oscillator circuit is comprised of an amplifier (U2) and two reactive components, an inductor L1 and a capacitor C4. The frequency of the oscillator

$$F = \frac{1}{2\pi\sqrt{LC}}$$

The amplifier U2 shown in Figure 1 is a high speed CMOS hex inverter. The resistor R2 is used to bias the input of the amplifier to compensate for the leakage current. The resistor R3 and capacitor C3 provide the feedback path. A transistor amplifier or operational amp will also work in place of hex inverter U2. The circuit shown in Figure 1 has two output signals, a sine wave (CT1 pin 2) and a DC voltage value (CT1 pin 4). The diode D2 and capacitor C5 rectify the sine wave output to a DC voltage value. The transistor Q2 is used to add some drive current to the DC voltage output signal. The inductor L1 is the coil in the sensors described here.

Sensor

Fig 2 shows a sensor of the type used in the current invention. The coil of the sensor is coil L1 in Fig 1. With this sensor the coil is mounted into a core made of a magnetic material (for example ferrite) that has an E shaped cross section. In operation an electromagnetic field is projected from the face of the sensor defined by the open side of the E shape. When the metal actuator moves into the field, eddy currents are created in the actuator that interfere with the field. Inductor resistance is increased causing the voltage output of the circuit to decrease. An example of this change in output of the circuit as the actuator intersects more and more of the field produced by the sensor is depicted in Fig 3.

Rotary motion resolution

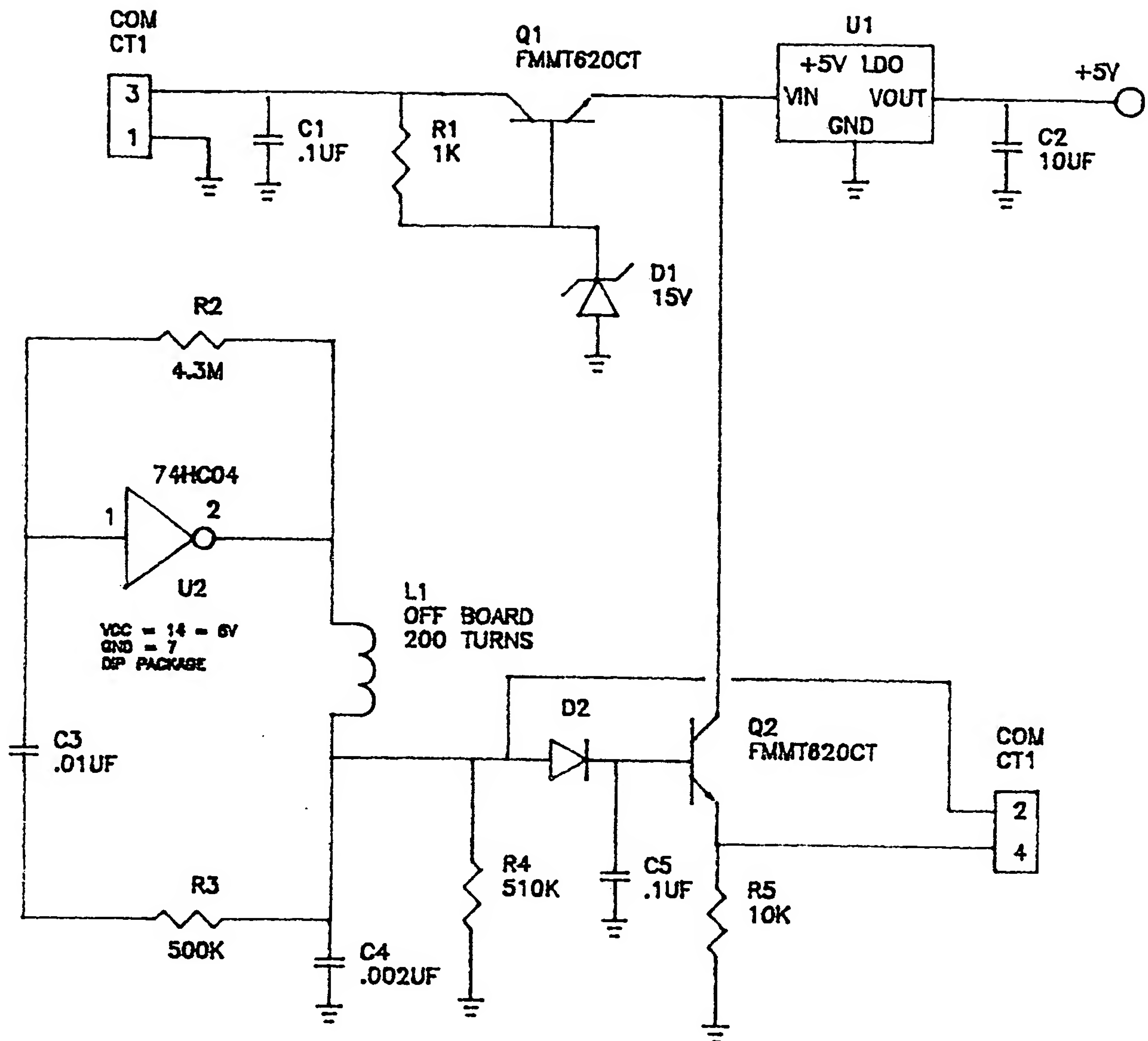
Fig 4 shows actuator and sensor arrangement for resolving rotary motion. A sensor of the type of Fig 2 is rigidly affixed to a mount. A shaft protrudes through a hole in the mount and is able to rotate in the hole. The shaft is not able to move axially in the hole. An actuator plate is affixed rigidly to the shaft so that the planner surfaces of the actuator plate are perpendicular to the axis of the shaft. The outside edge of the metal actuator plate has a spiral shape. When the shaft and actuator assembly rotates about the axis of the shaft a greater or lesser amount of metal interacts with the field produced by the sensor. This causes the output of the sensor circuit to change. By judicious choice of the shape of the actuator the output of the sensor circuit can be adjusted for various angular displacements of the shaft. The output may be made linear with angular movement or it may be made to have abrupt changes and/or plateaus. The design of the actuator in Fig 4 might be used with a shaft that rotates alternately clockwise and counter clockwise over an angel of less than 360 degrees. In that case, one particular voltage value will be output by the circuit for any particular angular location of the shaft. Position of the actuator-shaft assembly will be detected when it is moving and when it is at rest.

Fig 5 shows an alternate design for an actuator plate. An actuator plate of this shape might be used when the shaft to which it is attached rotates for 360 degrees or more. In this case when the shaft is rotated for 360 degrees the output of the circuit will fluctuate from its high value to its low value and back to its high value. Position of the plate at rest is only known at the angular position corresponding to the high voltage reading and to the position at the low voltage reading. Otherwise there are two angular positions that have the same voltage output. However, if the shaft always rotates in one direction, either clockwise or counterclockwise, then angular position can be determined once there is rotation of the shaft. Once rotation occurs, then voltage is either increasing or decreasing. The voltage output value and the fact of increasing or decreasing voltage allows the circuit that receives output from the circuit of Fig 1 to identify angular position. Alternately, an electronic latch can be used that latches at the high voltage and unlatches at the low voltage or vise versa. Then combination of the latch state and voltage value of the circuit of will indicate position of the actuator–shaft assembly.

In Fig 4 and Fig 5 actuators are shown that have an actuator surface that moves radially in relation to the axis of rotation. Fig 6 and Fig 7 show actuators that have actuator faces that move axially with rotation of the actuator-shaft assembly. The output of the device depicted in Fig 6 is similar to the output of the device depicted in Fig 4. The output of the device depicted in Fig 7 is similar to the output of the device depicted in Fig 5.

Sensors of the type depicted in Fig 2 and used here are sensitive to motion of the actuator in the direction perpendicular to the face on the sensor. One application where the device shown in Fig 4 might find application is for detecting angular position of throttle shafts used with internal combustion engines. However, axial run out of throttle shafts is inherent in the design of the mechanisms currently in use. Fig 8 shows a device that compensates electronically for axial run out of the shaft. Two sensors of the type used in Fig 4 are rigidly held in a mount so that they face each other and are parallel to each other. The actuator plate is mounted midway between the two sensors. Axial movement of the actuator-shaft assembly causes the inductive resistance of one sensor coil to decrease while causing the other sensor coil to have an increase in inductive resistance. By summing the inductive resistance of the two coils, here called L1 and L2, the effect of axial movement of the actuator-shaft assembly on voltage output of the devise is reduced.

Fig 9 shows the two coils wired in series in the circuit of Fig 1. Fig 10 shows the coils wired in parallel. Both ways are effective in lessening the effect of axial run out of the shaft.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R1
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VIN
VOUT
GND
+5V
C2
10UF
D1
15V
R2
4.3M
74HC04
1
2
U2
VCC = 14 = 6V
GND = 7
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L1
OFF BOARD
200 TURNS
C3
.01UF
D2
Q2
FMMT620CT
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CT1
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R3
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R4
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C4
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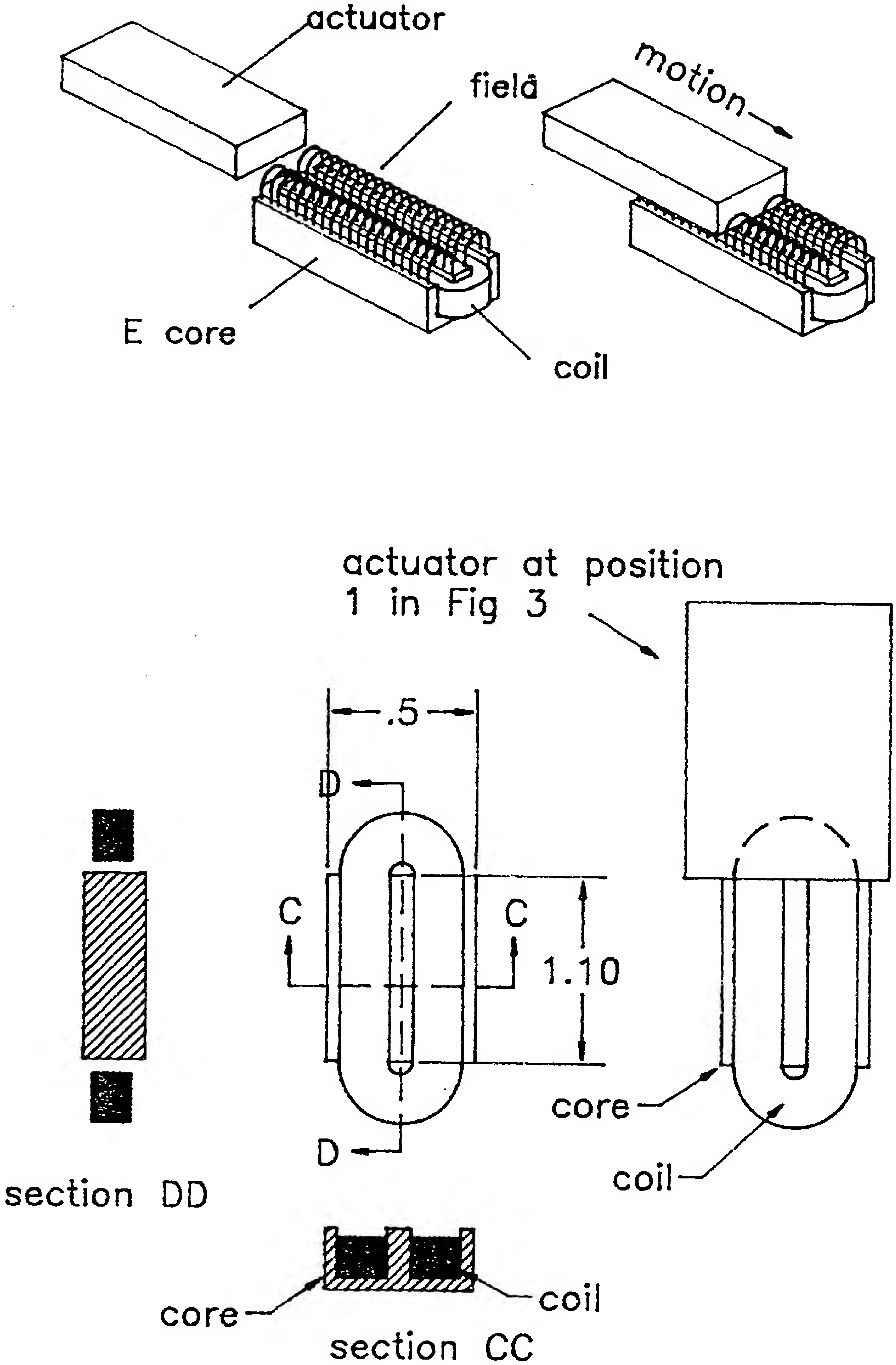
Fig 1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field
motion
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coil
actuator at position
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D
C
C
1.10
core
coil
D
section DD
core
coil
section CC

Fig 2

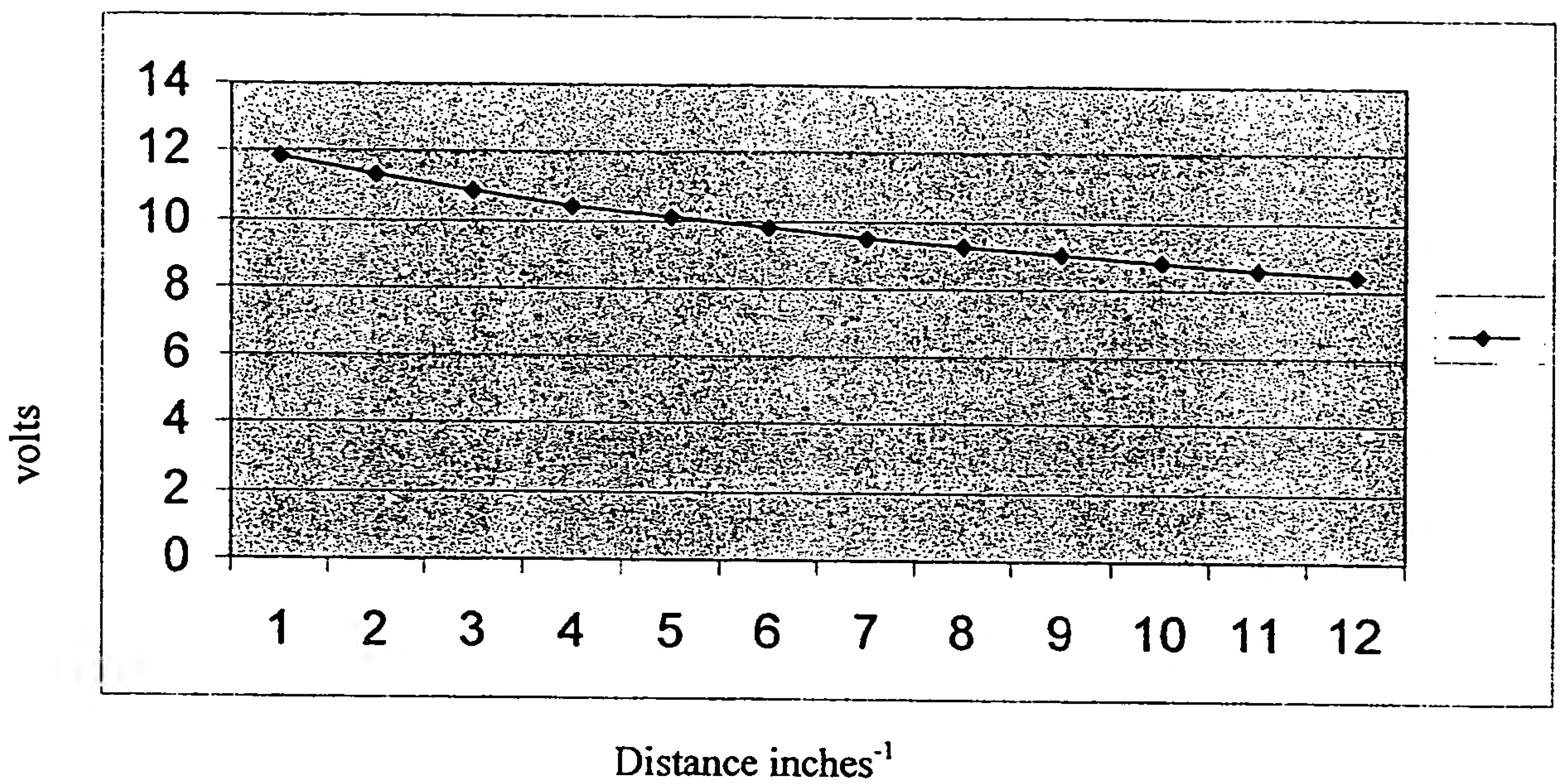
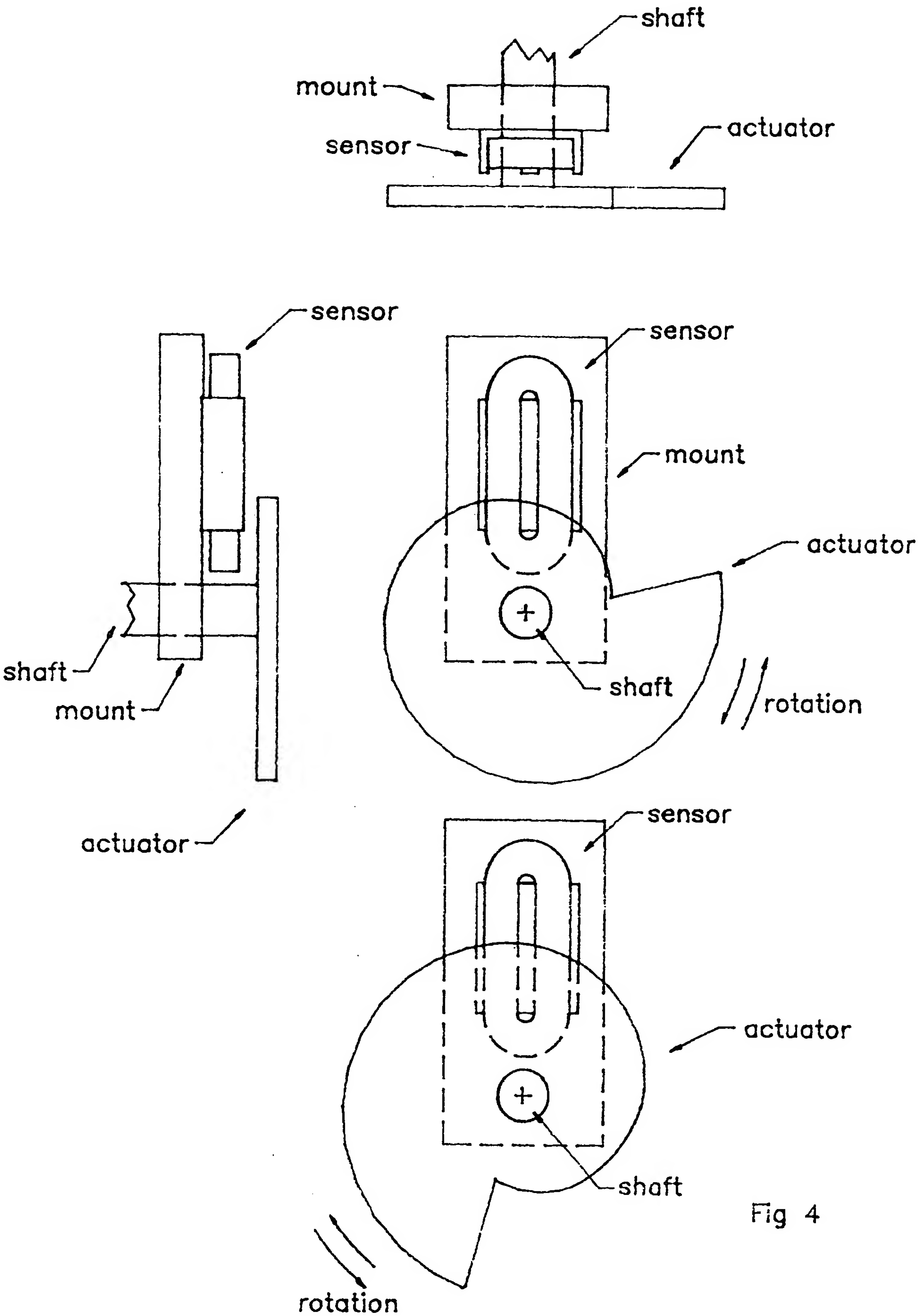


Fig 3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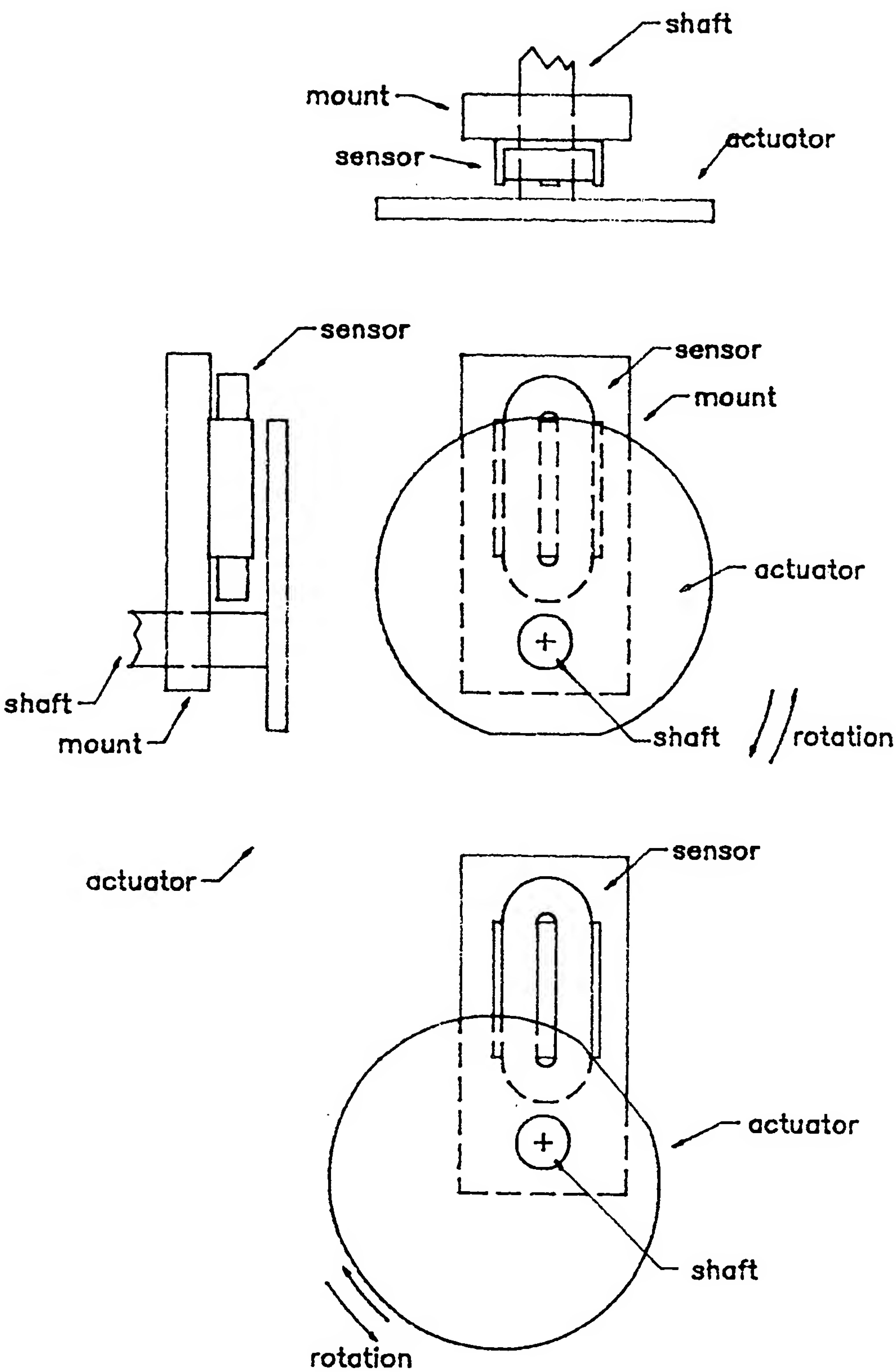
mount
sensor
actuator
sensor
sensor
mount
actuator
shaft
mount
shaft
rotation
actuator
sensor
actuator
shaft
rotation

Fig 4


shaft
mount
sensor
actuator
sensor
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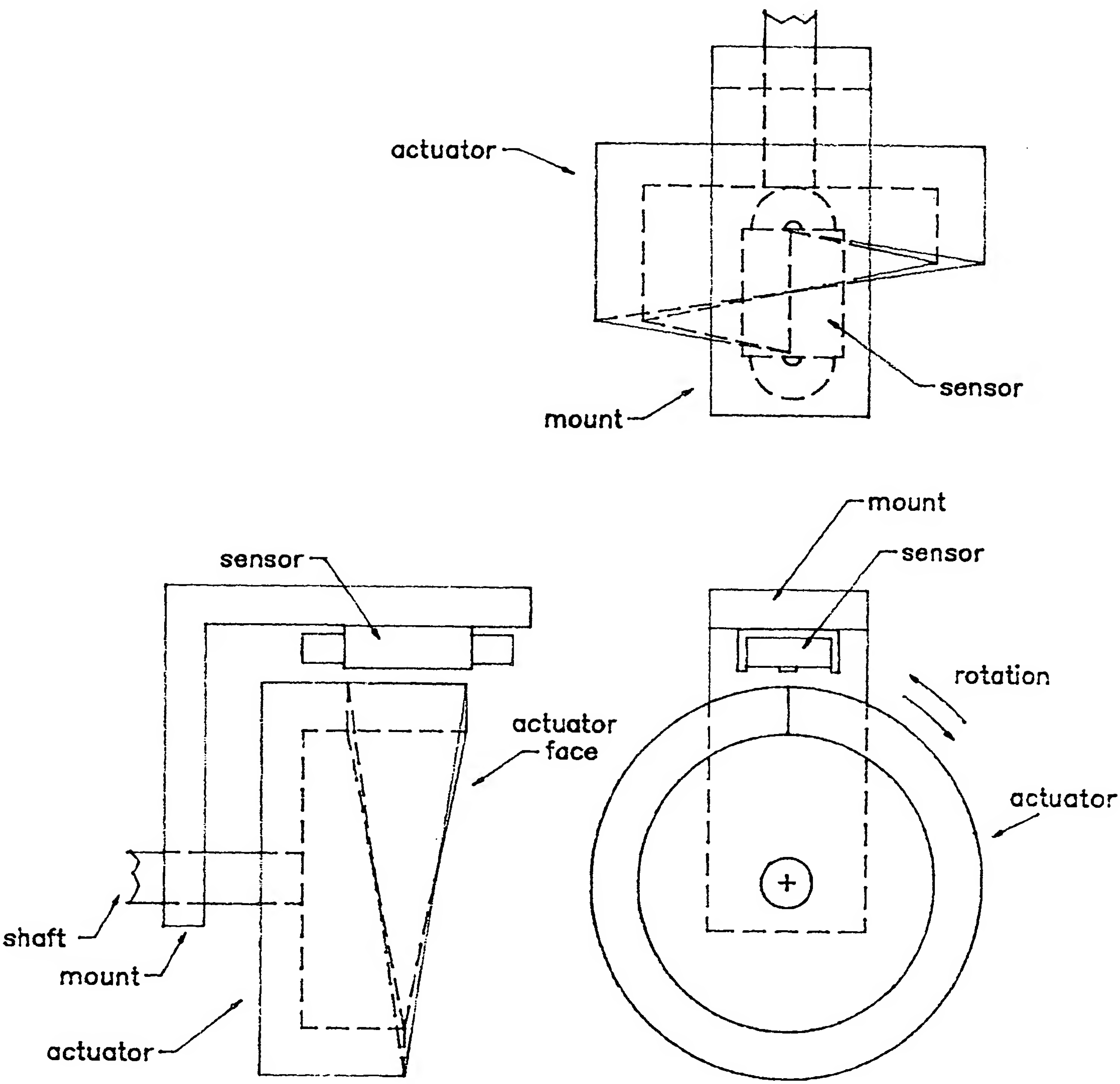
shaft
mount
shaft
rotation
actuator
sensor
actuator
shaft
rotation

Fig 5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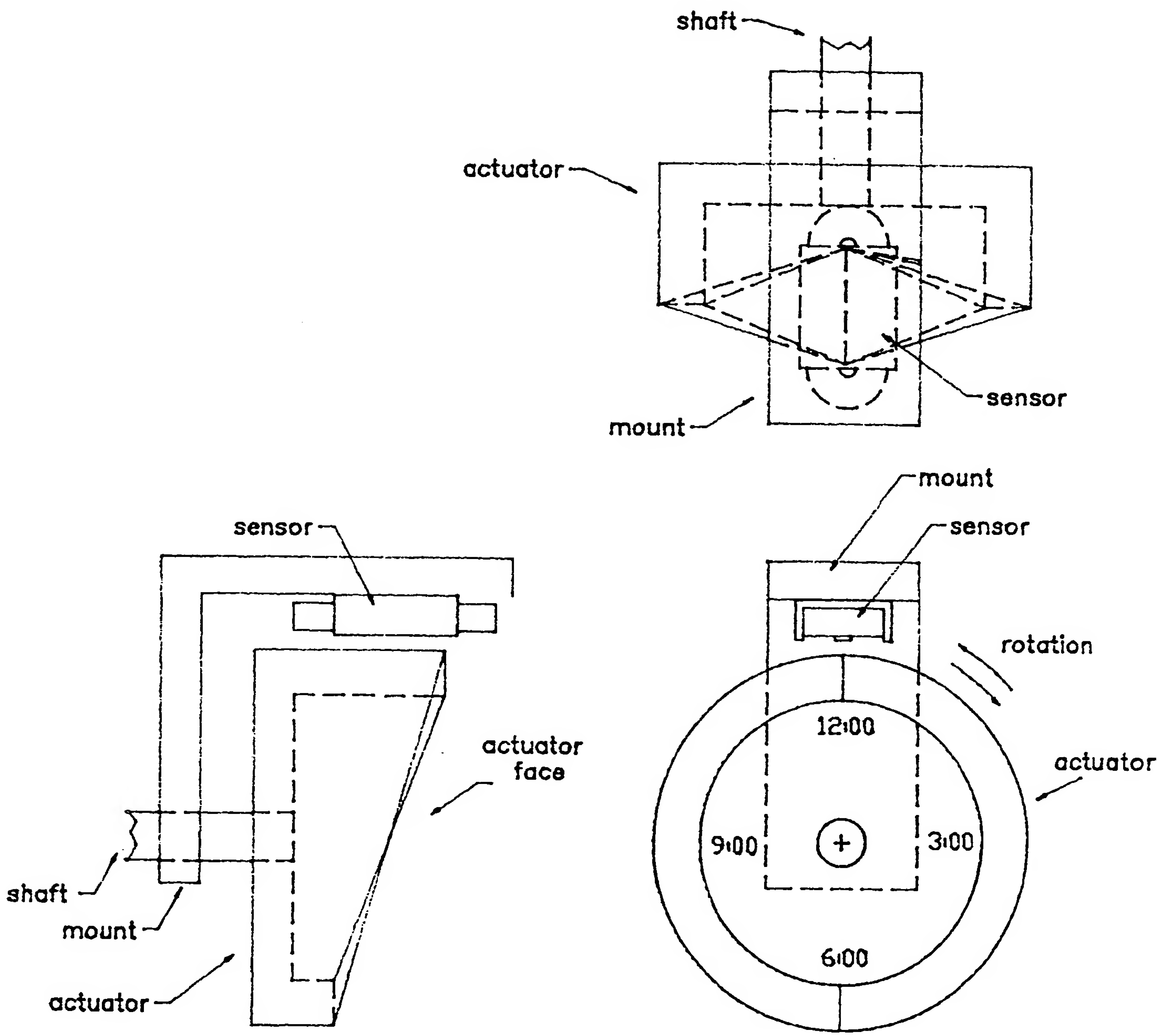
sensor
sensor
rotation
actuator face
actuator
shaft
mount
actuator

fig 6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sensor
mount
sensor
actuator
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mount
actuator
mount
sensor
rotation
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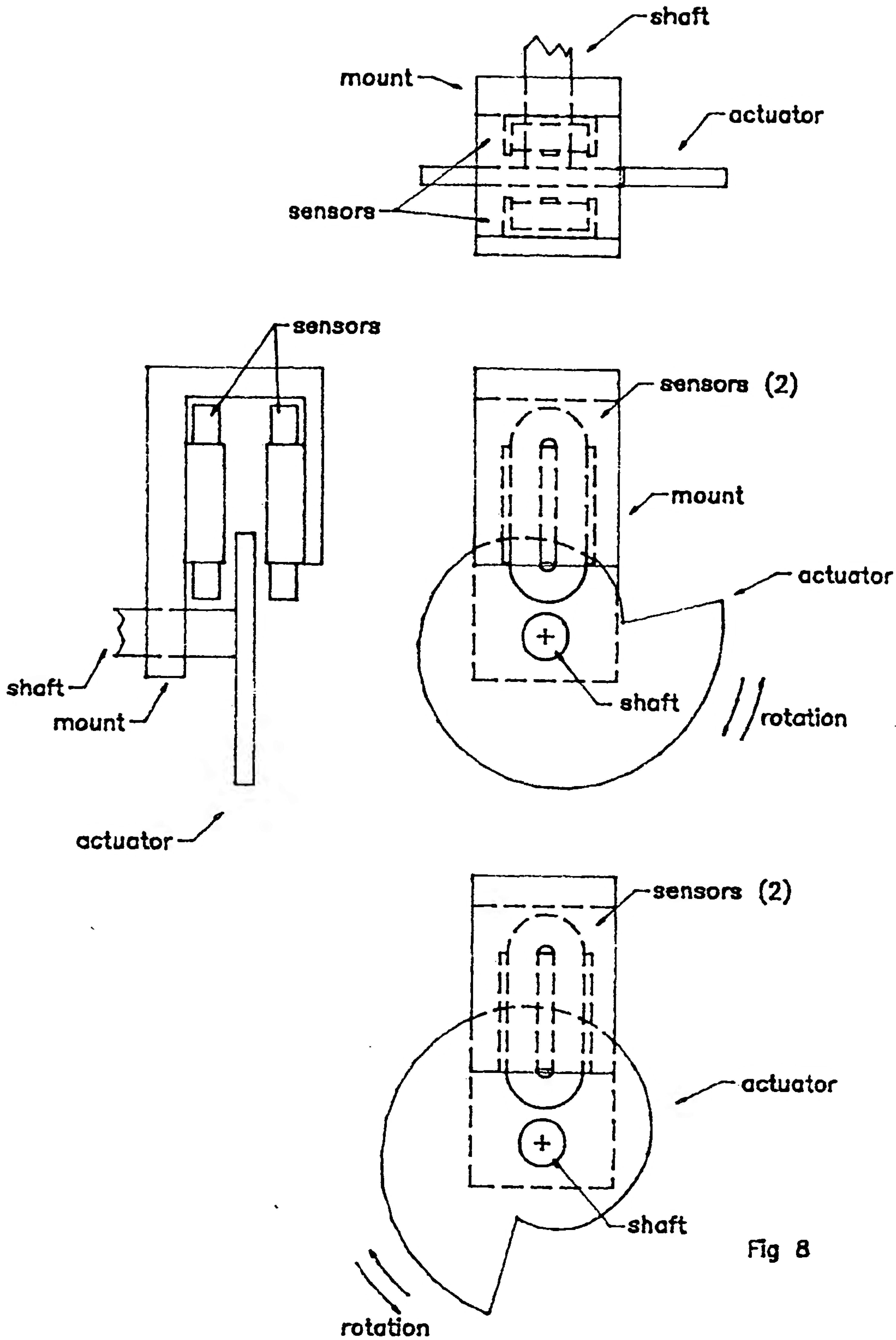
actuator
9:00
3:00
6:00

fig 7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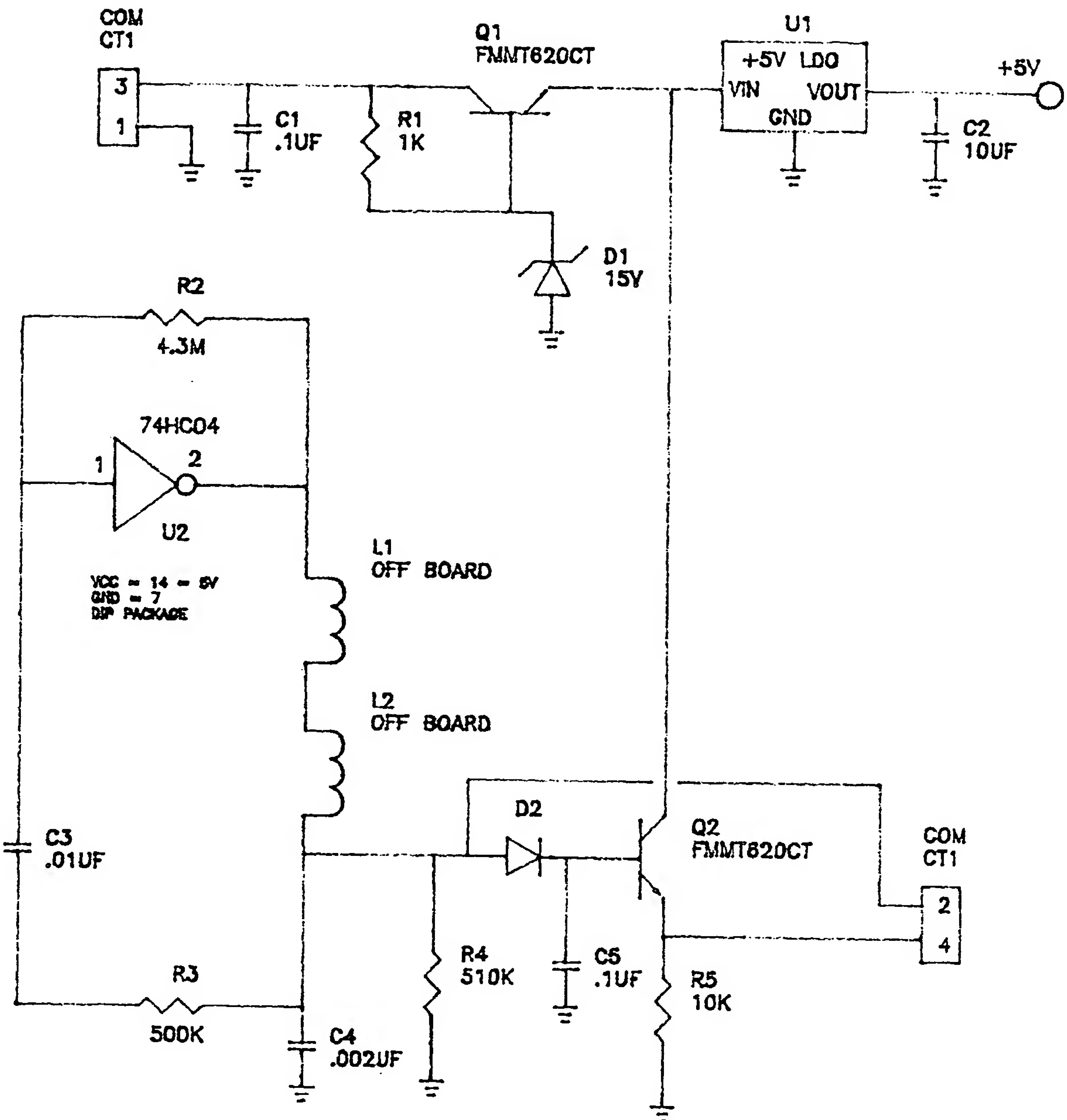
mount
actuator
sensors
sensors
sensors (2)
mount
actuator
shaft
mount
shaft
rotation
actuator
sensors (2)
actuator
shaft
rotation

Fig 8



COM
CT1
3
1
C1
.1UF
R1
1K
Q1
FMMT620CT
U1
+5V LDO
VIN
VOUT
GND
+5V
C2
10UF
D1
15V
R2
4.3M
74HC04
1
2
U2
VCC = 14 = 5V
GND = 7
DIP PACKAGE
L1
OFF BOARD
L2
OFF BOARD
C3
.01UF
D2
Q2
FMMT620CT
COM
CT1
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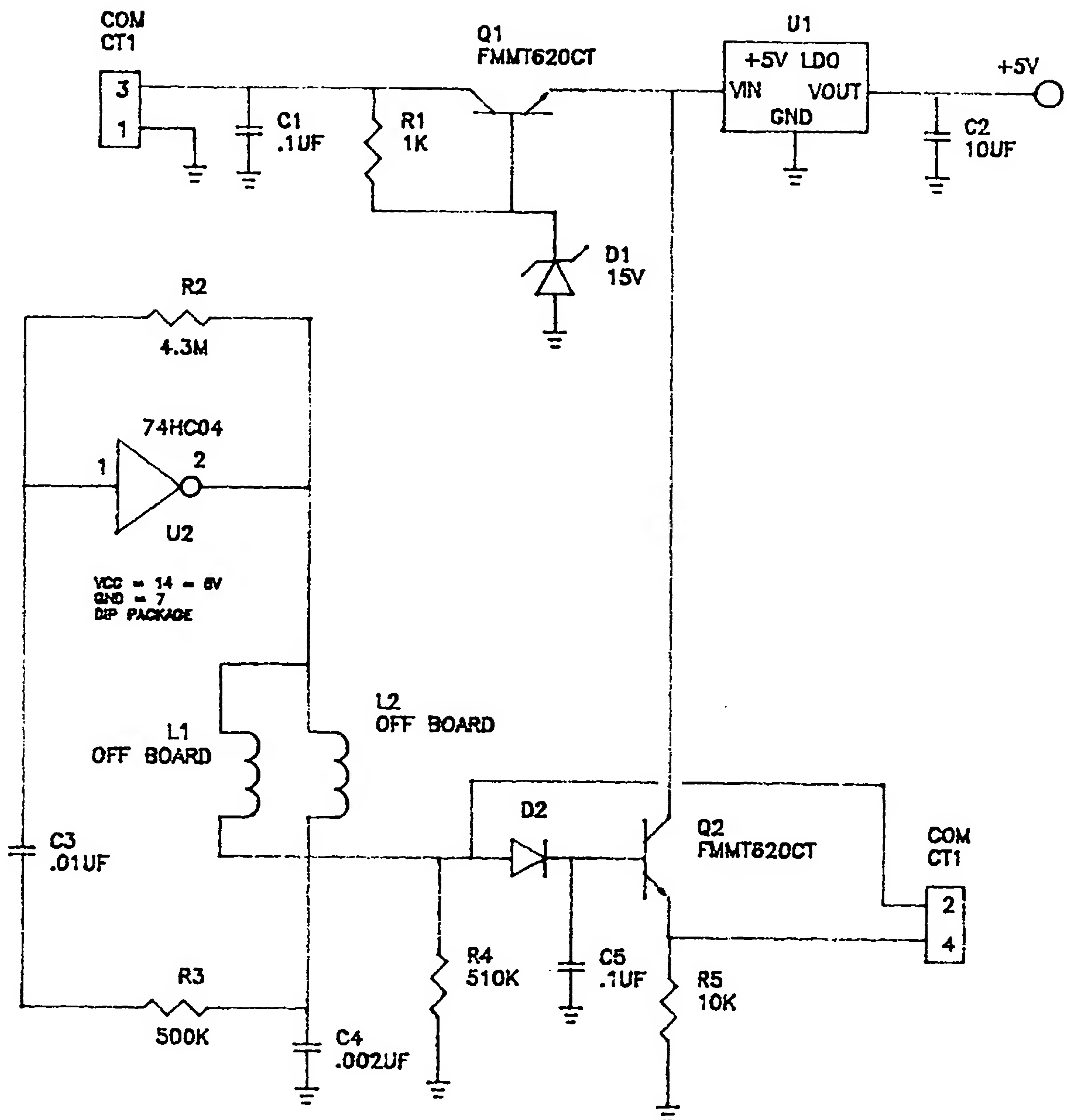
R4
510K
C5
.1UF
R5
10K
R3
500K
C4
.002UF

Fig 9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CT1
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R1
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FMMT620CT
U1
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VIN
VOUT
GND
+5V
C2
10UF
D1
15V
R2
4.3M
74HC04
1
2
U2
VCC = 14 = 5V
GND = 7
DIP PACKAGE
L1
OFF BOARD
L2
OFF BOARD
D2
Q2
FMMT620CT
COM
CT1
2
4
C3
.01UF
R3
500K
C4
.002UF
R4
510K
C5
.1UF
R5
10K

Fig 10